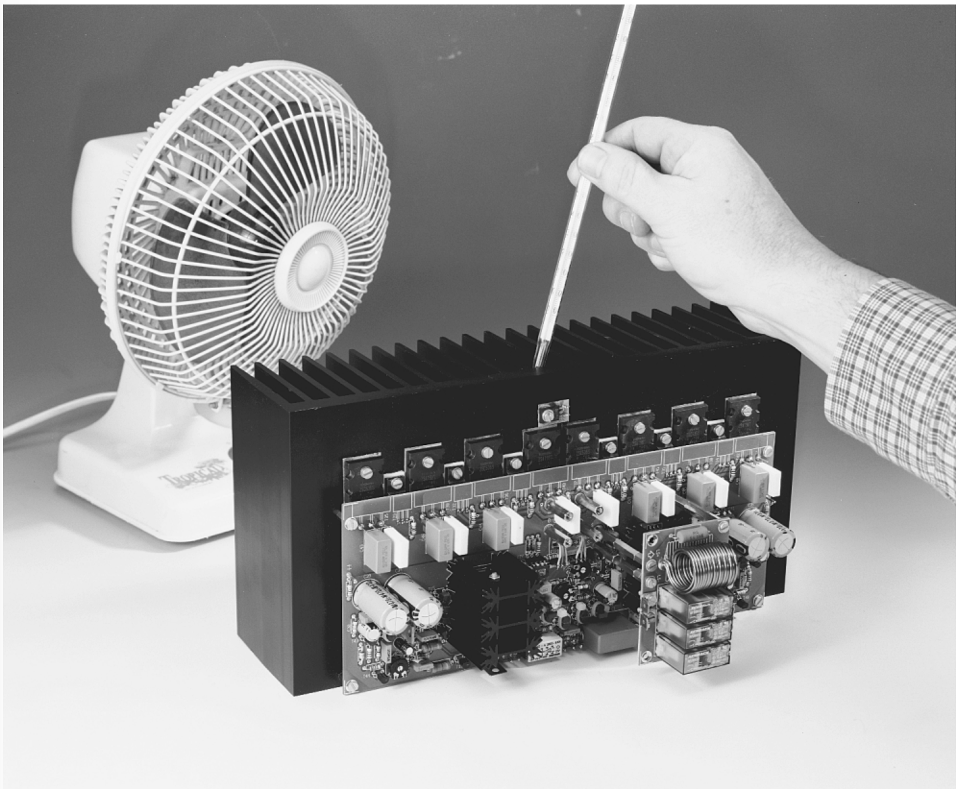
fan control

for high-power output amplifiers



Most domestic amplifiers are cooled solely by convection, but it may happen that a standard heat exchanger does not provide adequate cooling for a certain output amplifier. In such a case other means must be used, normally a fan or fans. The circuit described in this article provides a temperature-dependent, proportional control for such a cooling fan. It enables the turn-on threshold and the control characteristic to be set as needed within a given range. It also provides over-temperature indication which may be used to actuate the protection circuit of the amplifier.

Design by T. Giesberts

INTRODUCTION

Although the heat sink of the Titan 2000 is of reasonable dimensions, the amplifier, like other output amplifiers, has its limits as regards dissipation. With loads down to 4 Ω the heat sink is perfectly capable of dissipating the generated heat, but with lower loads and maximum drive levels, forced cooling must be used.

The design of the present circuit ensures that when a predetermined heat sink temperature is exceeded, two small fans are switched on which rotate at a speed that is directly proportional to the heat sink temperature. When maximum fan speed is reached, the over-temperature indication is enabled and the protection circuit of the ampli-

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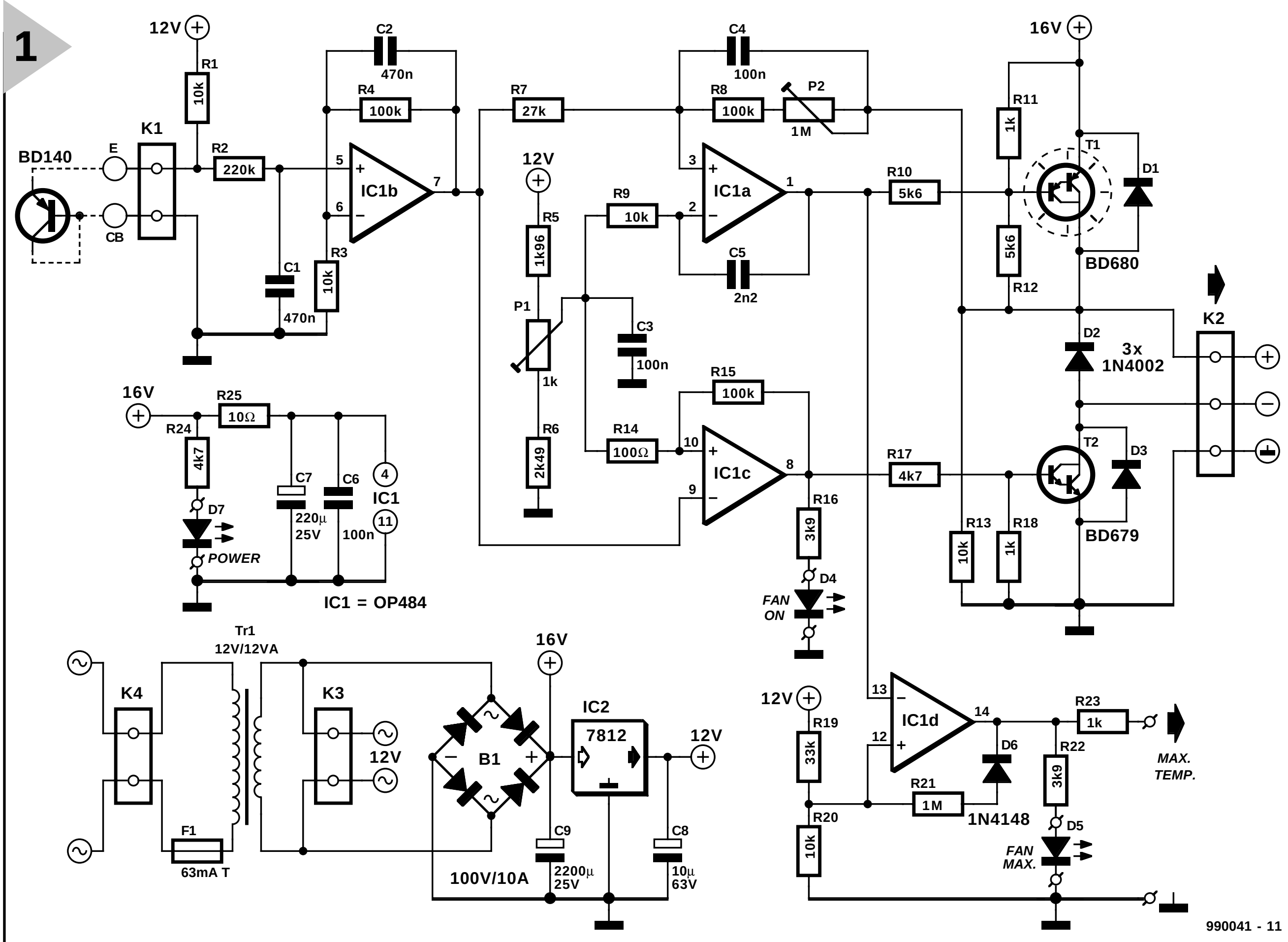

Figure 1. Two amplifiers, a pair of comparators and a couple of light-emitting diodes (LEDs) provide the desired control characteristic and indications.

fier may be actuated via a separate output.

There are two indicator LEDs: one for the turn-on threshold (when the fans are turned on), and the other for maximum temperature. The fans in the prototype are small 12 V models. The rotational speed of these can be varied readily with the supply voltage: they start reliably from voltages as low as 5 V. It is of great importance that the fans are very quiet types to avoid intrusive fan noise in the listening room during low programme levels.

The temperature sensor is a standard Type BD140 transistor mounted on the heat sink. Its forward voltage (like that of any silicon transistor or diode) decreases by exactly 2 mV °C^{-1}, which makes it eminently suitable for use as a sensor.

DESIGN

The circuit diagram of the control is shown in **Figure 1**.The over-temperature signal appears on pins ‘max temp’, the fans are linked to connector K_2, and the sensor is connected to K_1.

The sensor, which is arranged as a diode, is biased via resistor R_1. The temperature-dependent potential across the p-n junction is filtered by network R_2-C_1 and then amplified ×11 by operational amplifier IC_{1b}. To make sure that there is adequate control voltage for the fans, amplifier IC_{1a} provides additional gain. This op amp is arranged a an inverting amplifier to ensure that the control voltage is directly proportional to the heat sink temperature. Transistor T_1 provides the level of current needed by the fans.

Preset P_2 in the feedback loop sets the gain of IC_{1a} and thus the degree to which the control voltage follows the temperature-dependent sensor output.

The fans are switched on via IC_{1c}, which compares the output signal of IC_{1b} with the reference potential derived from network R_5-P_1-R_6. At a given threshold, set with P_1, IC_{1c} changes state, whereupon the –ve pin of K_2 is linked to earth, resulting in the fans being switched on. Diode D_4 lights to indicate this happening. The threshold set with P_1 is also used as a reference for IC_{1a} to ensure that the initial control voltage is equal to the switching threshold.

Circuit IC_{1d} provides the over-temperature indication signal. This comparator guards the output voltage of amplifier IC_{1a} and changes state when the fans are working at full speed. Diode D_5 lights and a high level is passed to the ‘max temp’ output via

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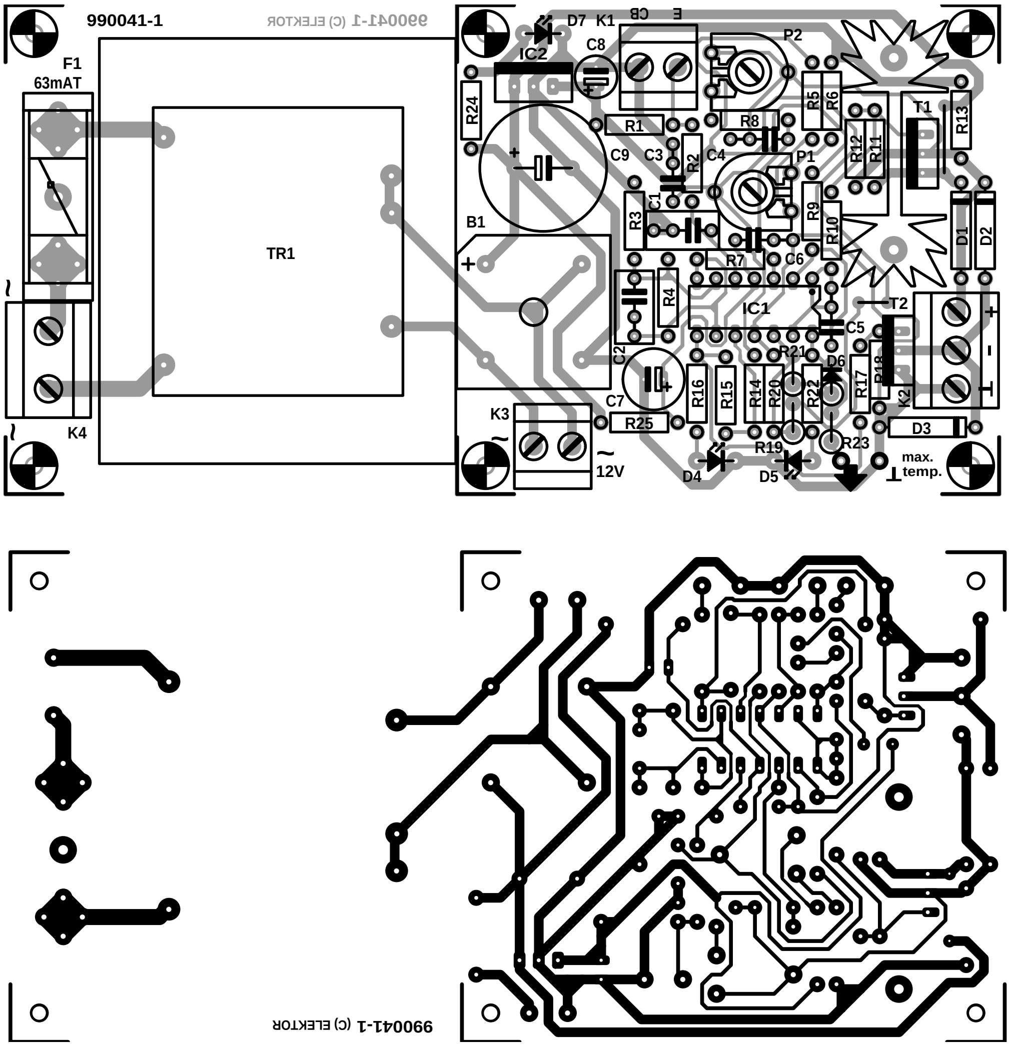
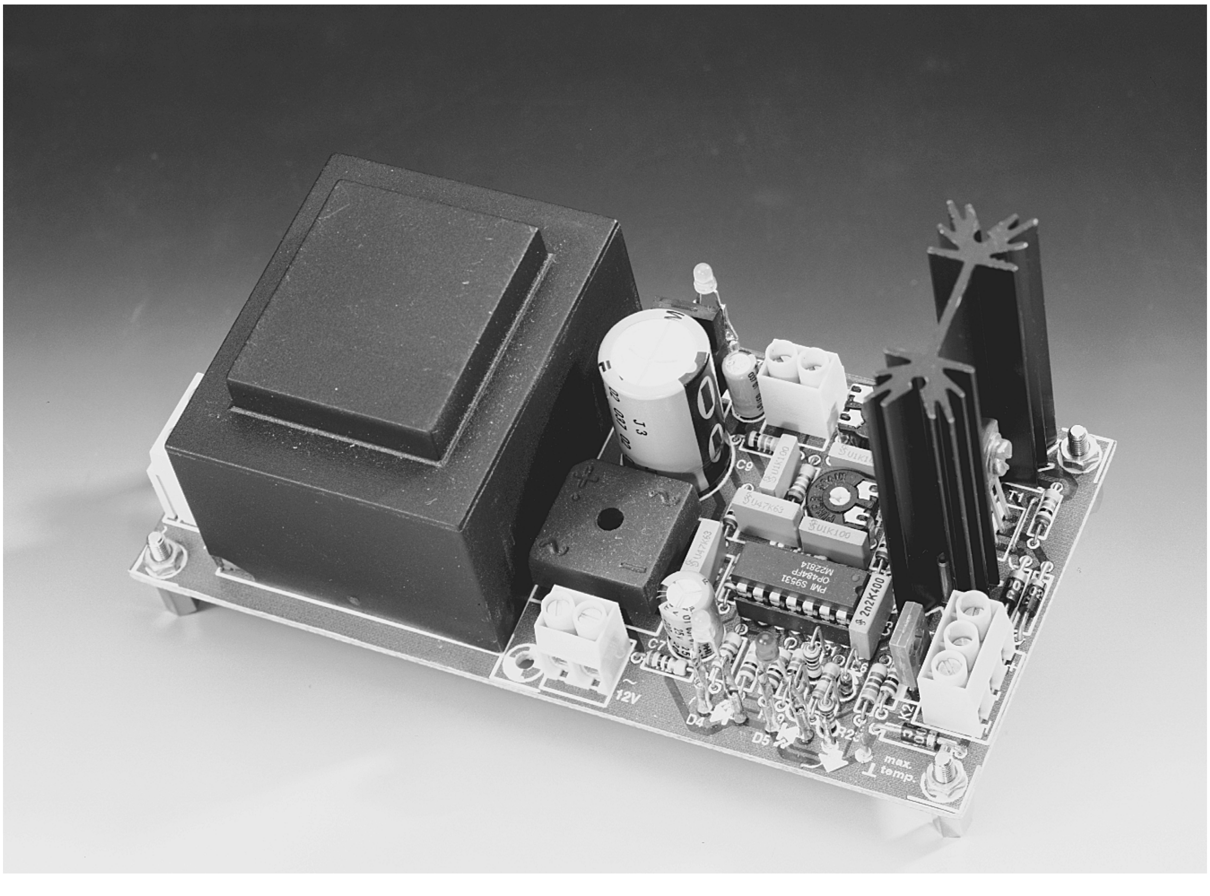

990041-1
990041-1 (C) ELEKTOR
F1
63mAT
TR1
K4
B1
K3
12V
IC2
D7
K1
CB
E
C8
P2
R24
R1
R8
R5
R6
T1
R13
C9
C3
R2
C4
P1
R12
R11
C1
R3
R9
R10
D1
D2
R7
C6
R4
IC1
T2
C5
R21
D6
C2
R16
R15
R14
R20
R22
R17
R18
K2
C7
R25
R19
R23
D3
D4
D5
max.
temp.

3



Parts list

Resistors:
R_1, R_3, R_9, R_{13}, R_{20} = 10 kΩ
R_2 = 220 kΩ
R_4, R_8, R_{15} = 100 kΩ
R_5 = 1.96 kΩ
R_6 = 2.49 kΩ
R_7 = 27 kΩ
R_{10}, R_{12} = 5.6 kΩ
R_{11}, R_{18}, R_{23} = 1 kΩ
R_{14} = 100 Ω
R_{16}, R_{22} = 3.9 kΩ
R_{17}, R_{24} = 4.7 kΩ
R_{19} = 33 kΩ
R_{21} = 1 MΩ
R_{25} = 10 Ω
P_1 = 1 kΩ preset
P_2 = 1 MΩ preset

Capacitors:
C_1, C_2 = 0.47 µF
C_3, C_4, C_6 = 0.1 µF
C_5 = 0.0022 µF
C_7 = 220 µF, 25 V, radial
C_8 = 10 ≤ F, 63 C, radial
C_9 = 2200 µF, 25 V, radial

Semiconductors:
D_1–D_3 = 1N4002
D_4, D_5, D_7 = high-efficiency LED, yellow red, green respectively
D_6 = 1N4148
T_1 = BD680
T_2 = BD679

Integrated circuits:
IC_1 = OP484FP (Analog Devices)
IC_2 = 7812

Miscellaneous:
K_1, K_3 = 2-way terminal strip for board mounting, pitch 5 mm
K_2 = 3-way terminal strip for board mounting, pitch 5 mm
K_4 = 2-way terminal strip for board mounting, pitch 7.5 mm
B_1 = rectifier, 100 V, 10 A, horizontal, 19×19 mm
Tr_1 = mains transformer, 12 V, 12 VA (see text for external transformer or mains adaptor)
F_1 = slow fuse 63 mA, complete with holder for board mounting
Heat sink (T_1), e.g., Fischer SK104/50
Two off 12 V fans (see text)
PCB Order no. 990041 (see Readers Services towards the end of this issue)

Figure 2. The design of the board allows the transformer section to be cut off.

Figure 3. Photograph of the completed prototype control.

resistor R_{23}. This high level may be communicated to the protection board in the Titan 2000 for use as a switching signal. In other amplifiers, it may be used via a buffer to, say, energize an output relay.

The supply for the circuit has been kept as simple as possible. The fans are driven by the rectified secondary voltage (16 V) of the transformer. The 16 V line is additionally decoupled by network R_{25}-C_6-C_7 for use as a supply for IC_1. The +12 V supply needed for the various references and setup networks is obtained by applying the 16 V voltage to IC_2. Diode D_7 functions as on/off indicator.

SETTING UP

The turn-on threshold is set with P_1 and the range of rotational speed of the fans with P_2. These settings are empirical and to individual requirements, for which an accurate thermometer is required.

Two extreme settings are possible. The first is with the turn-on threshold fairly high (60–65 °C) and maximum gain. The maximum rotational speed will then occur at a temperature only 6–7 °C higher than the turn-on threshold. The second is to set the turn-on threshold fairly low, say, 50 °C and the amplification low. This provides the largest possible control range, but the fans cannot reach maximum speed.

It is clear that the most practical setting is somewhere between these extremes. It is advisable to use a maximum heat sink temperature of 70 °C, in which case D_5 should light.

CONSTRUCTION

The control is best built on the printed-circuit board shown in **Figure 2**.

Since it may happen that the specified transformer cannot be obtained, the board may also be used with an external transformer or mains adaptor. The secondary of the transformer or the output of the mains adaptor is linked to the board via a two-way terminal strip for board mounting (K_3). If required, the transformer section of the board may then be cut off.

Since the dissipation of T_1 may rise to 6 W, the component must be mounted on a heat sink. If a Fischer Type SK104 is used, the supporting pins of this may be soldered to the board. An isolating washer is not strictly needed, but, since the collector of the transistor is linked to the case, care should be taken to ensure that the heat exchanger does not touch other components.

Figure 3 shows the completed prototype.

The sensor is connected to K_1 via two twisted lengths of thin, stranded, insulated circuit wire. Also, the output “max temp’ is linked to input ‘temp’ on the protection board via two twisted lengths of similar wire.

The light-emitting diodes (LEDs) are, of course, not placed on the board, but mounted on the front panel of the amplifier. They, too, are linked to the relevant positions on the board by twisted lengths of thin, insulated, stranded circuit wire.

The fans are connected in parallel to K_2.

When the control is used with the Titan 2000, all connections are shown on the wiring diagram of that amplifier (Part 4, Figure 16 elsewhere in this issue).

When the control is used with a public-address amplifier (PA), the fans may be connected to ‘+’ and ‘⊥’ on K_2 instead of to ‘+’ and ‘–’. If this is done, the fans are on continuously, but still at a speed that depends on the heat sink temperature.

The peak output current of the circuit is 1 A, which is more than adequate since most fans need only 200–250 mA.

The peak voltage available at K_2 is equal to the rectified transformer voltage less the knee voltages of T_1 and T_2. In practice, this is about 13 V.

[990041]